

NOAA Coral Reef Watch -- 2014 annual summaries of thermal conditions related to coral bleaching for U.S. National Coral Reef Monitoring Program (NCRMP) jurisdictions

Executive Summary

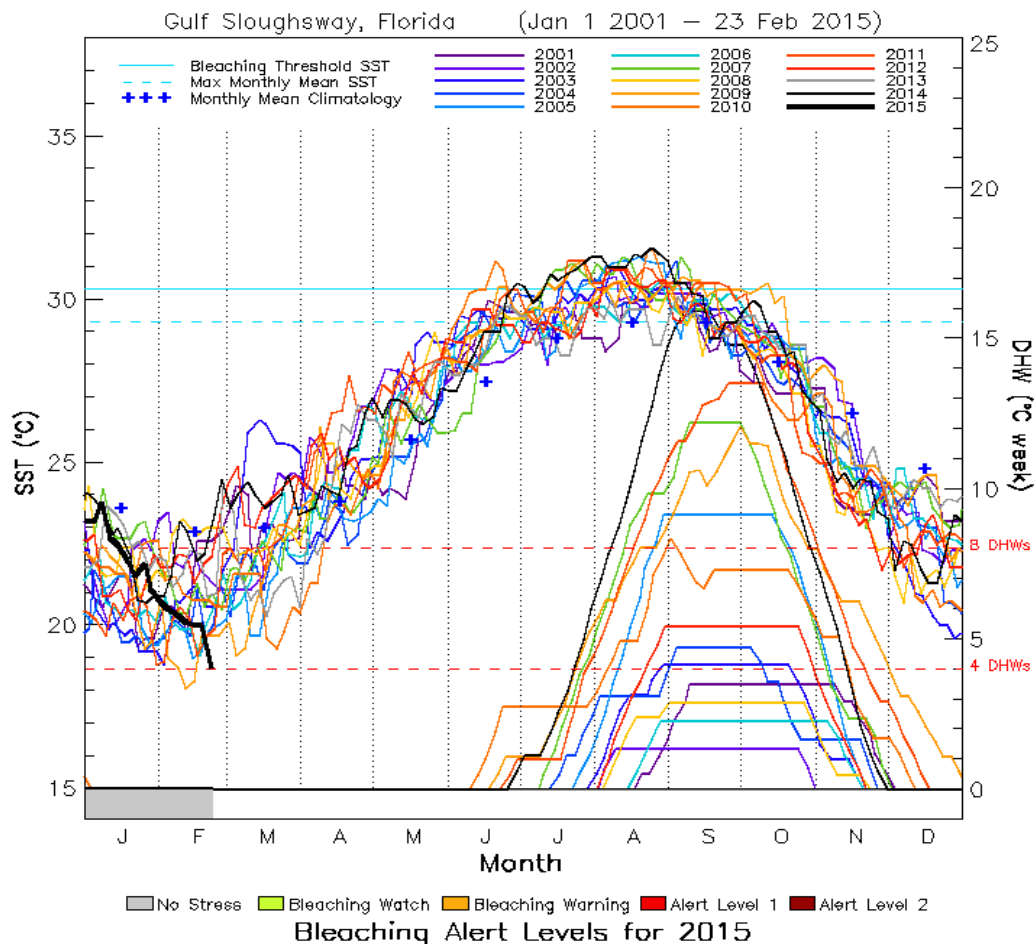
Although an El Niño did not fully develop in 2014, ocean warming events hit many major U.S. coral reef jurisdictions, both in the Pacific and Atlantic Oceans. In fact, 2014 is one of only a few years on record that witnessed bleaching of U.S. coral reefs on such a large spatial scale, including record-breaking events in the Hawaiian Islands and the Commonwealth of the Northern Mariana Islands (CNMI) and bleaching in Guam and the Florida Keys.

While NOAA Coral Reef Watch's (CRW) heritage, operational twice-weekly 50-km satellite coral bleaching thermal stress monitoring products continued to alert coral reef communities to the development of bleaching thermal stress, in 2014, CRW also implemented an updated version of its next-generation daily 5-km satellite coral bleaching thermal stress monitoring products. The 5-km products included sea surface temperature (SST), SST Anomaly, Coral Bleaching HotSpot, Degree Heating Week, and a 7-day maximum Bleaching Alert Area composite. They provided much higher spatial (5-km) and temporal (daily) resolutions and a revised climatology, which allowed them to monitor thermal conditions globally at or near reef scales. The 5-km products became available in May 2014, in time to monitor thermal conditions during the eventful 2014 boreal coral bleaching season, described below for the U.S. coral reef jurisdictions. (Note that the 5-km figures below utilize the new color palettes/scales developed for CRW's 5-km product images to provide improved visualization and interpretation of underlying data.)

Florida:

After unusually warm winter and spring seasons in the Florida reef tract (see example multi-year time series graph from Gulf Sloughsway, FL – Figure 1), NOAA CRW's operational twice-weekly 50-km satellite products monitored coral bleaching thermal stress initially starting June 23-26, 2014. A Bleaching Warning was issued for the Florida Bay starting July 10-13. A few weeks later, July 31-August 3, the entirety of the Florida Keys experienced a minimum thermal stress level of Bleaching Warning, with stress in Florida Bay being elevated to Alert Level 1 (significant coral bleaching). Of note, CRW's new 5-km satellite coral bleaching products, at much finer spatial and temporal resolutions than the operational 50-km products, indicated that even greater thermal stress (Alert Level 1) had developed on the gulf side of the lower Florida Keys by July 23, and had spread throughout the Keys up to Biscayne National Park by about August 20, 2014. By late July, local partners were reporting increasing water temperatures and signs of paling and/or partial bleaching of corals in the Florida Keys, especially *Porites* and *Agaricia* (*Undaria*), and smaller colonies of *Siderastrea* and *Meandrina* at forereefs. Partners also reported bleaching of multiple coral species at Summerland Key (Lower Keys), Hawks Channel (Middle Keys), Cheeca Rocks (Middle Keys), Biscayne National Park, off Key Biscayne, and along the coast of Miami-Dade County. By August 20, 2014, when CRW's satellite monitoring, especially the 5-km products, was showing that most of the Florida Keys was experiencing significant thermal stress (up to Alert Level 2 – widespread coral bleaching and mortality – in parts of the Lower Keys), local monitoring networks were reporting paling to significant bleaching of coral colonies throughout the region. In particular, severe bleaching was reported at Hawks Channel, where most staghorn corals and nearly all brain and massive corals were affected, and off Miami-Dade County.

Figure 1. Multi-year time series graph for Gulf Sloughsway, Florida. Note that unusually warm winter and spring sea surface temperatures (SSTs) in 2014 (thin black line) led to significant thermal stress in Florida from late July through August.



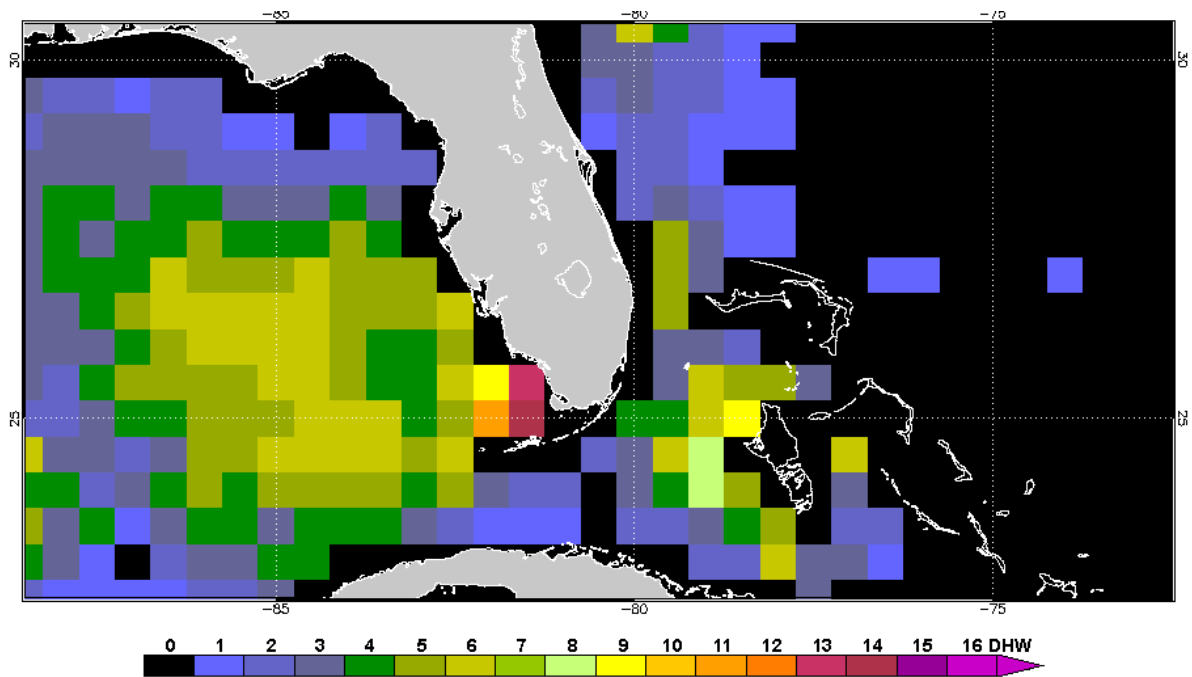


Figure 2. NOAA CRW Monthly Maximum 50-km Degree Heating Week (DHW) for Florida – August 2014.

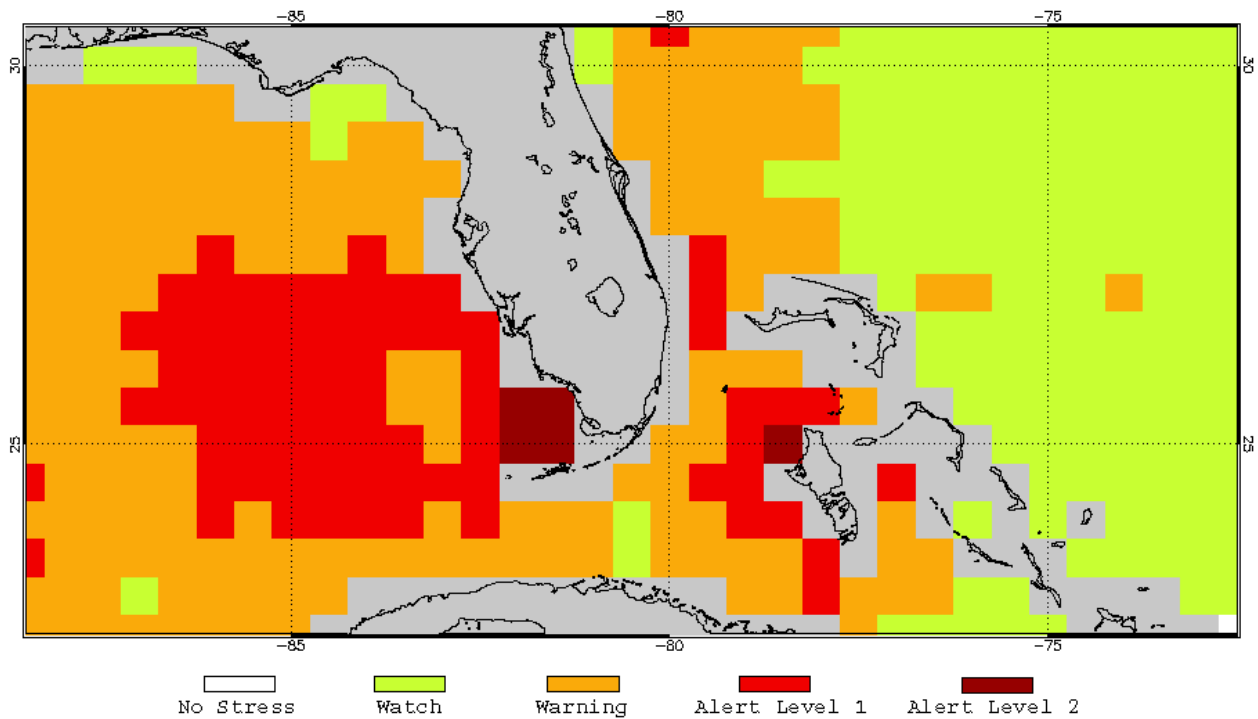


Figure 3. NOAA CRW Monthly Maximum 50-km Bleaching Alert Area for Florida – August 2014.

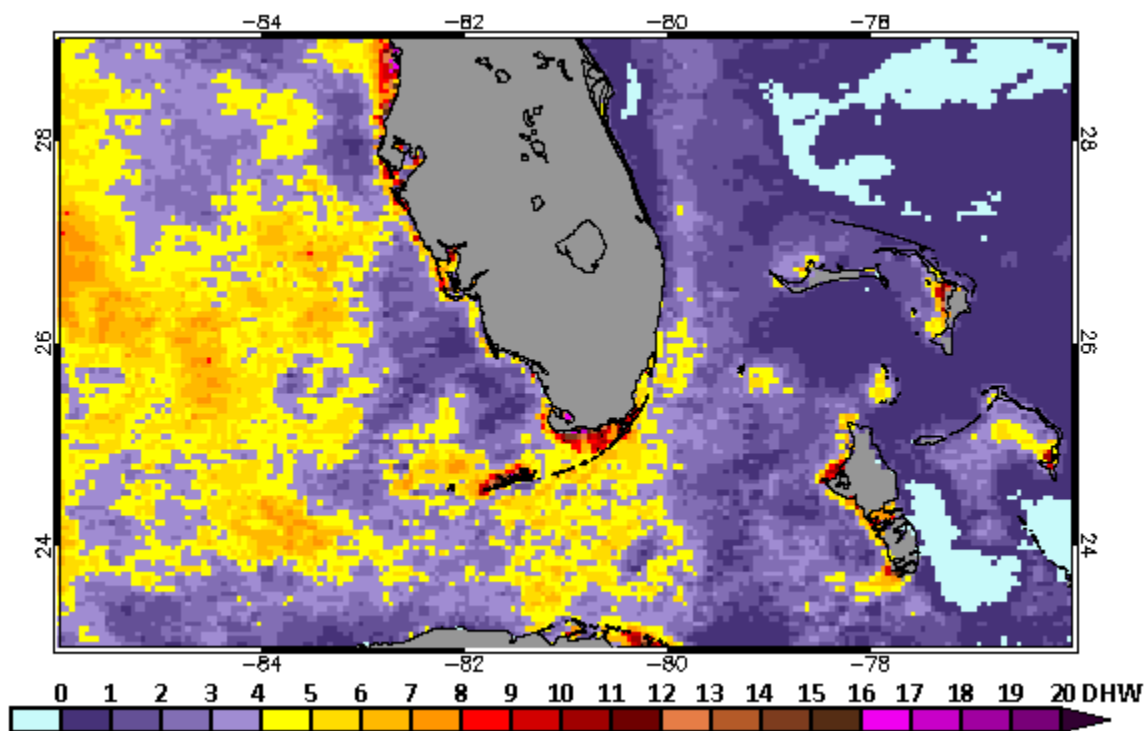


Figure 4. NOAA CRW Monthly Maximum 5-km DHW for Florida – August 2014.

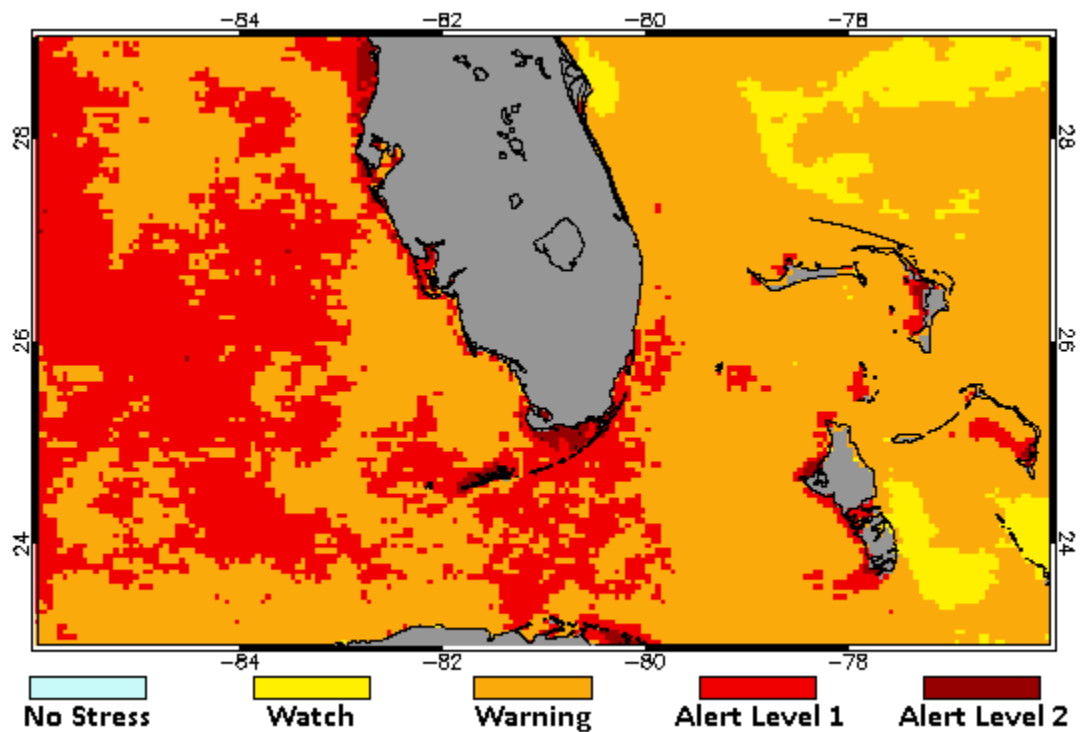


Figure 5. NOAA CRW Monthly Maximum 5-km Bleaching Alert Area composite for Florida – August 2014.

Puerto Rico:

NOAA CRW's satellite monitoring (at 50-km and 5-km resolutions) indicated little to no coral bleaching thermal stress for this region for 2014.

U.S. Virgin Islands:

NOAA CRW's satellite monitoring (at 50-km and 5-km resolutions) indicated little to no coral bleaching thermal stress for this region for 2014.

Hawaii:

Starting in late August 2014, NOAA CRW monitored substantial thermal stress leading to coral bleaching across the Hawaiian archipelago. By early October, CRW's daily global 5-km satellite coral bleaching thermal stress monitoring product suite showed thermal stress reaching Alert Level 2 (Figure 6), associated with significant, widespread coral bleaching and mortality, in many locations within the Northwestern Hawaiian Islands (NWHI, the area encompassed by the Papahānaumokuākea Marine National Monument, PMNM). Of note, the 2014 thermal stress records for the region ($DHW > 12$, Figure 7a) were higher than the record set in the 2002 bleaching event ($DHW < 8$, Figure 7b). In the main Hawaiian Islands (MHI), where island-wide mass coral bleaching had never been reported, thermal stress reached Alert Level 1 (significant bleaching) in Kauai and O'ahu. With the epicenter of the thermal stress located near Lisianski Island (Figure 7a) and the spatial coverage of the highest thermal stress extending along a vast area of the central NWHI (from Midway Atoll to French Frigate Shoals, Figure 6), this bleaching event impacted all of the Hawaiian Islands (both NWHI and MHI). In contrast, the 2002 unprecedented bleaching event in this region impacted only the western and central portions of the NWHI. Furthermore, the thermal stress in the 2014 event lasted much longer (about three months, August-October; Figures 7a-b and 8a-c) with higher SST anomalies than the 2002 event (Figure 9a-f), allowing the cumulative impact of the thermal stress in 2014 to significantly surpass that of the 2002 event. CRW's satellite- and climate model-based outlook products were used extensively by Hawaii's Division of Aquatic Resources (DAR) Eyes of the Reef program and local marine resource managers to support planning and prioritization of resources and to assist in-situ surveys and bleaching response efforts by Hawaii's coral reef monitoring networks. Elevated SSTs and bleaching thermal stress levels measured by CRW's 50-km and 5-km products were confirmed by in-water bleaching observations by the DAR and NOAA, along with academic and NGO partners (including the Hawaii Institute of Marine Biology and The Nature Conservancy) in the Northwestern Hawaiian Islands at Midway, Lisianski, and Maro islands and in the main Hawaiian Islands around O'ahu, Maui, and Kauai. The severity of coral bleaching throughout the Hawaiian archipelago, which local managers were alerted to by CRW's satellite data and products, as well as the modeled Four-Month Bleaching Thermal Stress Outlook, resulted in press releases being issued by the DAR and PMNM, and elevated media coverage of the bleaching event by major national news outlets such as *NBC News*, the *Huffington Post*, *USA TODAY*, *ABC News*, and the *Star Advertiser*, among others. Additionally, in response to CRW's bleaching alerts for the Hawaiian archipelago, one of CRW's major partners, the Catlin Seaview Survey, deployed a team to O'ahu, where severe bleaching had been reported, to collect 360° panoramic imagery of the local coral reefs. This high-resolution imagery, as with all underwater imagery collected by the Catlin Seaview Survey, will be incorporated shortly into Catlin's Global Reef Record and Google's Oceans – Street View, a Google Maps tool. Videographers from Exposure Labs also joined the Catlin Seaview

Survey team to film their activities as part of a documentary being developed on the severe coral bleaching expected in 2015 (in association with a potential, weak El Niño).

CRW's satellite early warnings provided critical and timely information for both the unprecedented 2002 (first, known widespread bleaching event in the NWHI) and the 2014 bleaching events in the remote, uninhabited NWHI. These alerts allowed local coral reef managers to quickly mobilize, re-focus, and maximize the efficiency of in-situ surveys associated with the events.

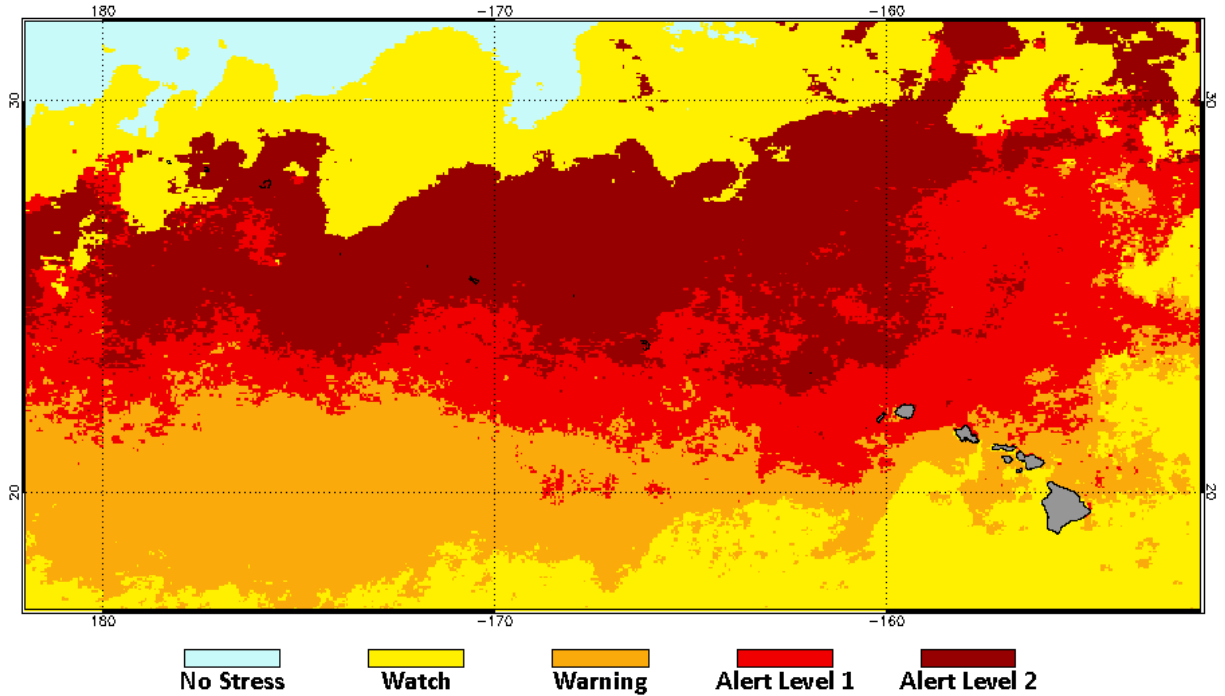


Figure 6. NOAA CRW 5-km Bleaching Alert Area (7-day maximum) composite for the Hawaiian Islands – October 13, 2014.

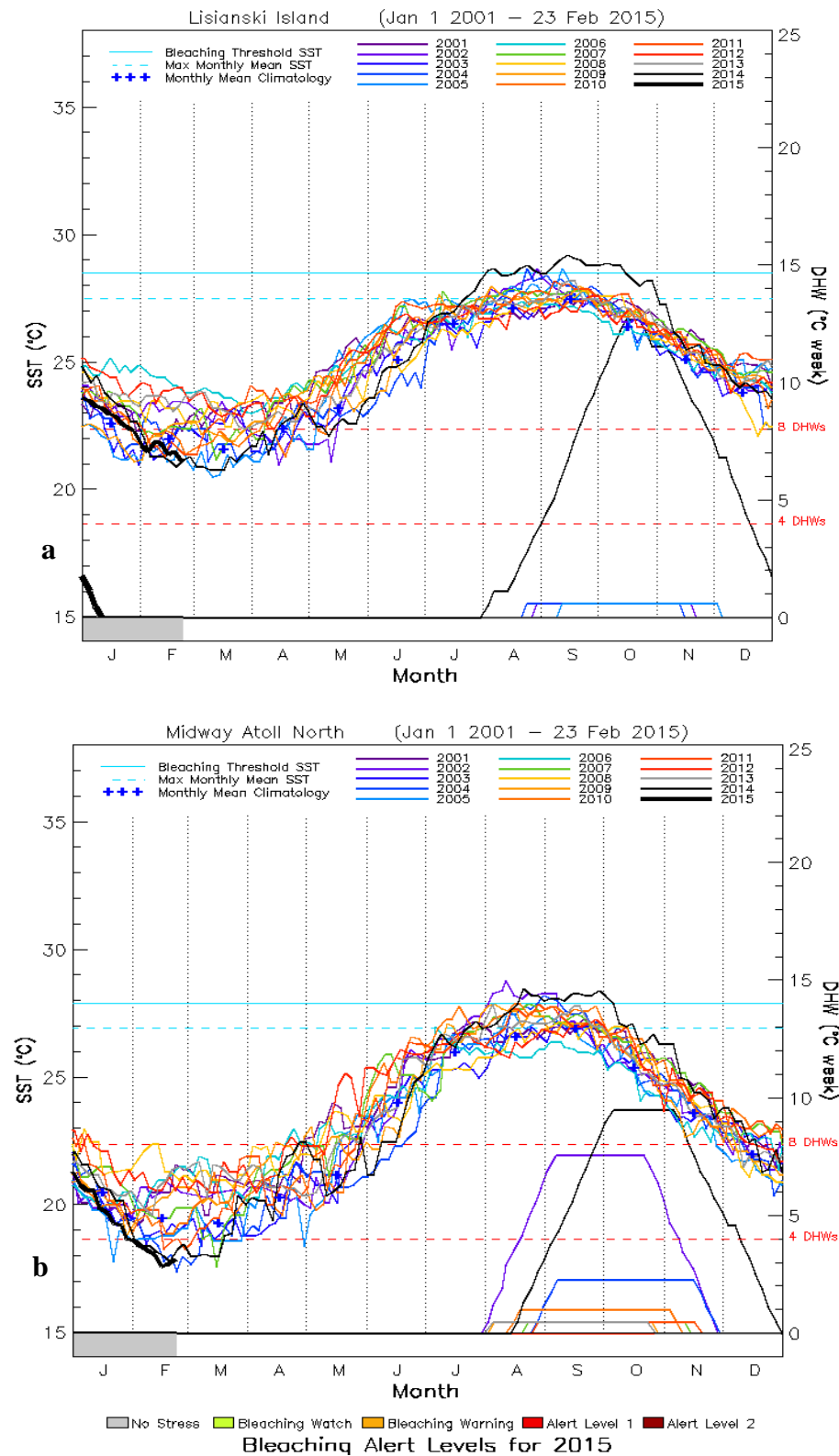


Figure 7. Multi-year time series graphs for: (a) Lisianski Island (epicenter of the 2014 Hawaiian Islands bleaching event, with DHW >12, thin black line at bottom of graph); and (b) Midway Atoll North (epicenter of the 2002 record bleaching event, with DHW <8, thin purple line at bottom of graph).

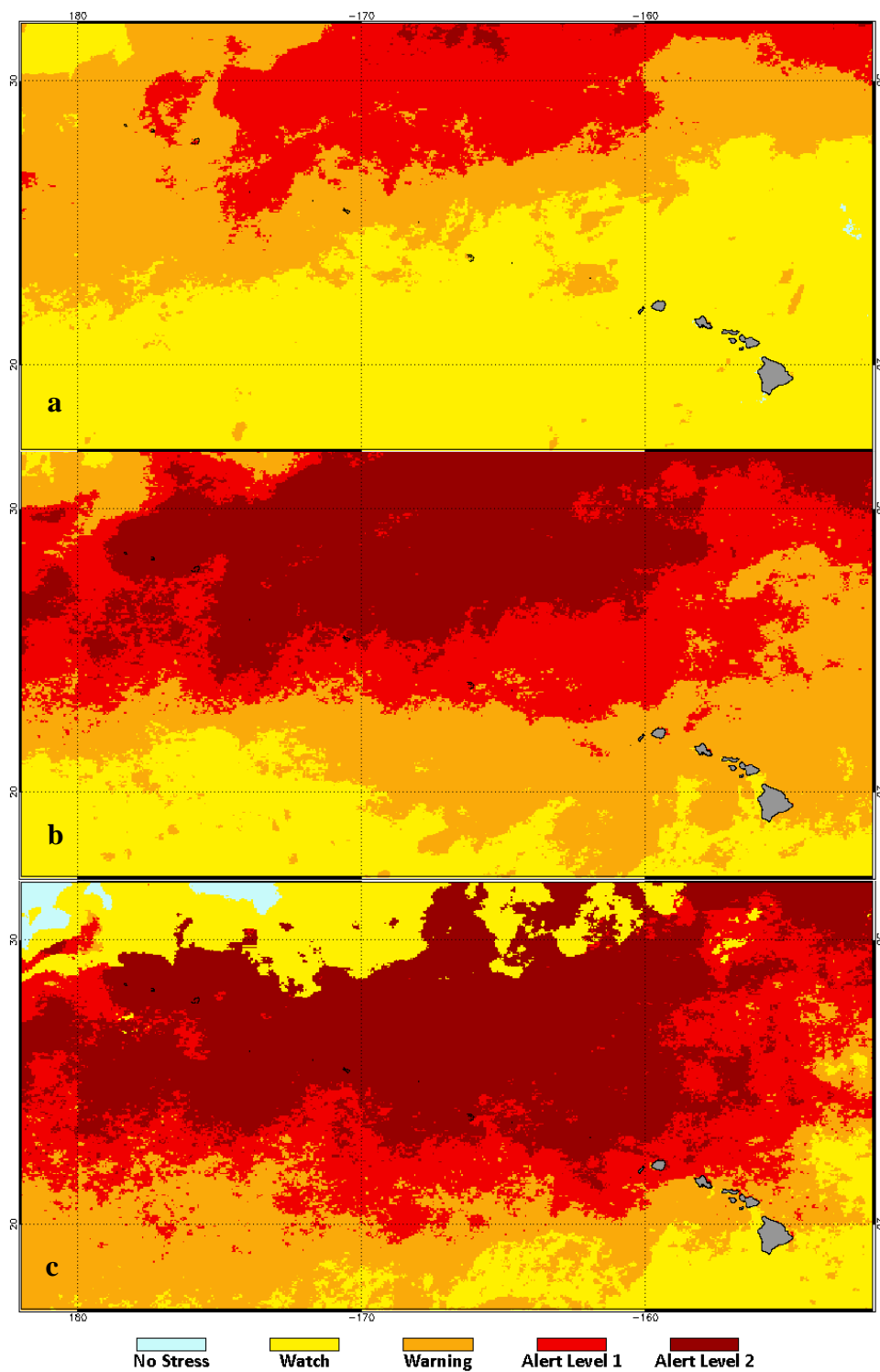


Figure 8. NOAA CRW Monthly Maximum 5-km Bleaching Alert Area composite for the Hawaiian Islands from (a) August, (b) September, and (c) October 2014.

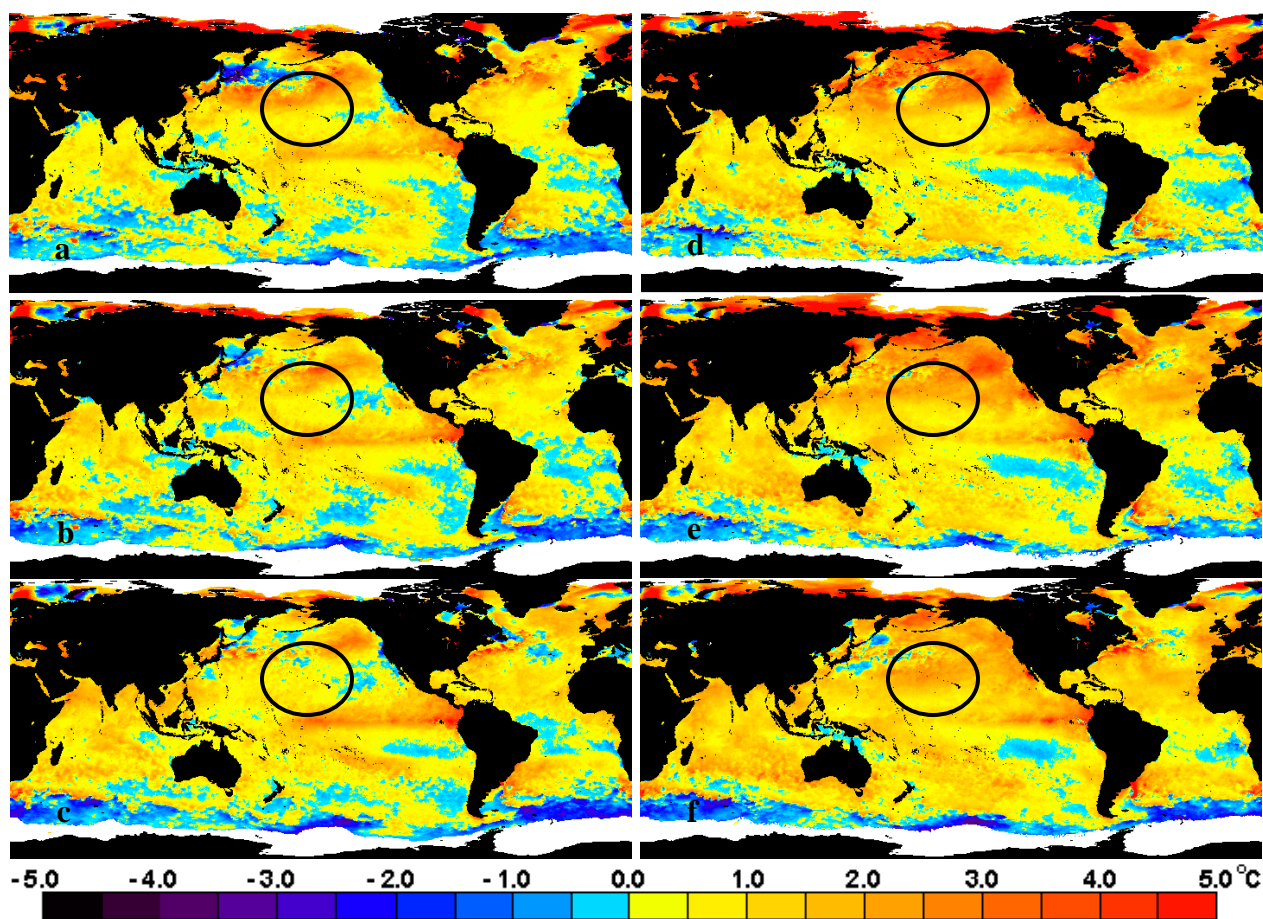


Figure 9. NOAA CRW Monthly Maximum global 50-km SST Anomaly (with the Hawaiian Islands circled in black) for: (a) August, (b) September, and (c) October 2002, and (d) August, (e) September, and (f) October 2014. Consistently higher satellite SST anomalies were monitored between August-October 2014 than August-October 2002, which was a record-setting bleaching event in the region.

American Samoa:

NOAA CRW's satellite monitoring showed that as of October 2014, American Samoa was under a Bleaching Watch (Figure 10), which remained in effect through December 2014 (Figure 11). As of December 30, 2014, however, CRW's weekly Four-Month Coral Bleaching Thermal Stress Outlook (Figure 12) predicted that the Bleaching Watch throughout the region would elevate to a Bleaching Warning in mid-January 2015 and an Alert Level 1 (associated with significant coral bleaching) by mid-February 2015. As of December 2014, CRW was already communicating with local coral reef management partners throughout American Samoa and independent Samoa to alert them to the potential approaching bleaching event. As of this writing in February 2015, the thermal stress is continuing to increase and substantial bleaching has begun.

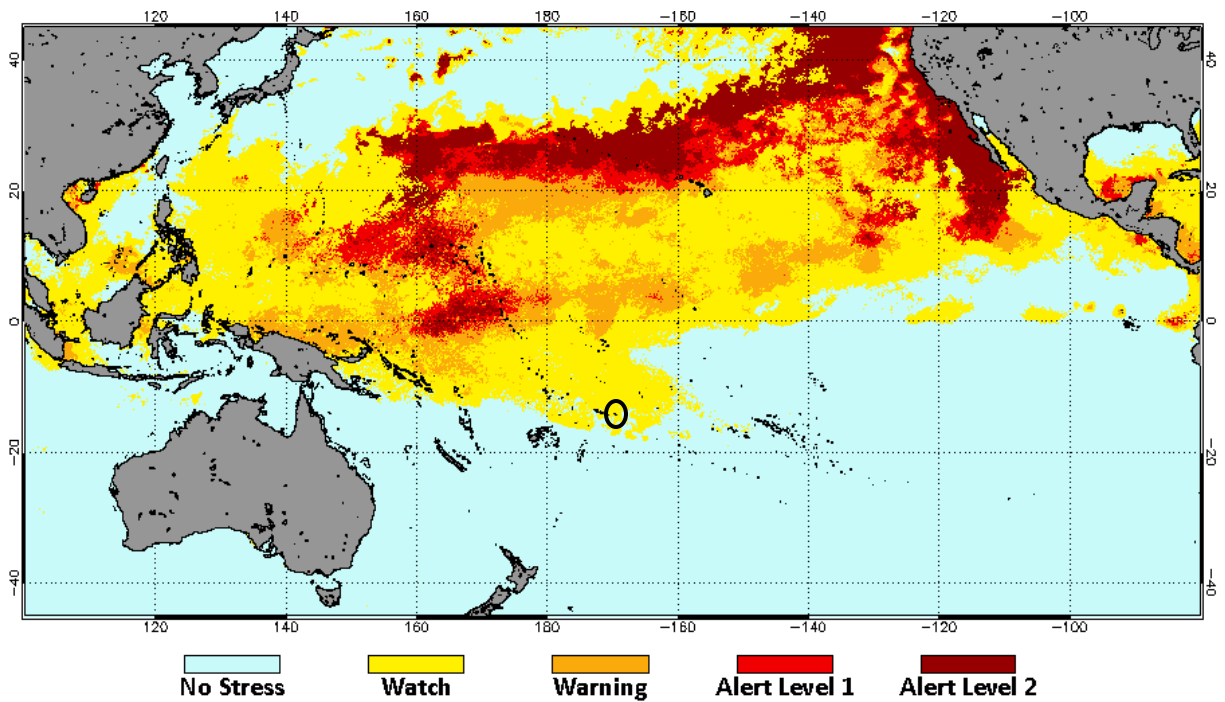


Figure 10. NOAA CRW Monthly Maximum 5-km Bleaching Alert Area composite for the Pacific (with American Samoa circled in black) – October 2014.

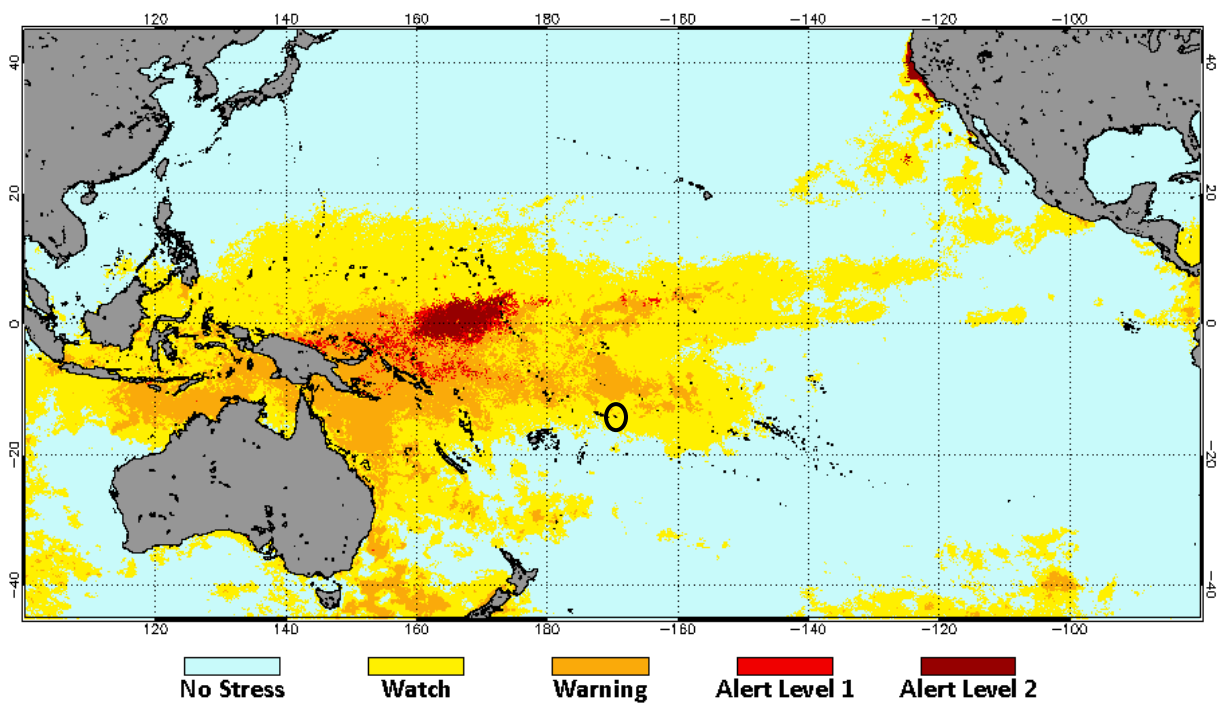


Figure 11. NOAA CRW Monthly Maximum 5-km Bleaching Alert Area composite for the Pacific (with American Samoa circled in black) – December 2014.

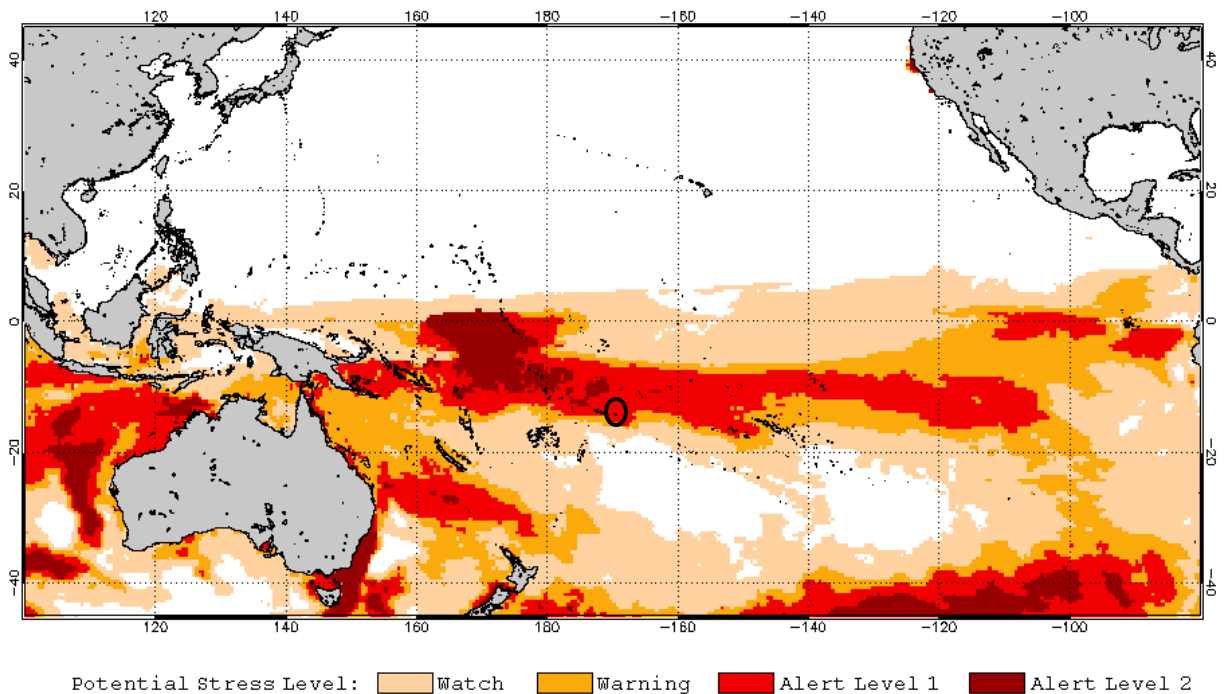


Figure 12. Map of potential coral bleaching (60% probability) in the Pacific Ocean for January-April 2015 from NOAA CRW's Four-Month Coral Bleaching Thermal Stress Outlook (version 3) of December 30, 2014, based on NOAA's Climate Forecast System v2 model. American Samoa is circled in black.

Guam and the Commonwealth of the Northern Mariana Islands (CNMI):

As in 2013, corals again experienced bleaching in Guam and the Commonwealth of the Northern Mariana Islands (CNMI) in 2014. On July 3, 2014, CRW's satellite monitoring detected substantial thermal stress (up to Alert Level 1) developing around Guam and throughout CNMI. CRW issued bleaching alerts based on both its 5-km (Figure 13a) and 50-km (Figure 13b) products and Four-Month Coral Bleaching Thermal Stress Outlook (Figure 14). The products were used by the local coral reef management community to activate its bleaching response plan (as in 2013) and enhance monitoring efforts on its reefs from July through September 2014 (the documented extent of the bleaching event). Local coral scientists and managers conducted reconnaissance level surveys of reefs to get a better understanding of the scope of the event; used traditional media, email, and social media to provide continuous update of the event and request the public's aid to observe and document the spatial extent and severity of bleaching; and photo-documented the bleaching at individual reefs. CRW's long-term satellite record indicates that this region is usually free of major coral bleaching thermal stress, but in 2014, as in 2013, significant thermal stress was experienced in the CNMI – especially the northernmost islands. Spatial distributions of thermal conditions monitored by the 5-km satellite products during the two 2014 events in the CNMI and Guam agreed with field observations of bleaching. Consistent with the thermal stress values in the 5-km products, bleaching observed in both the 2013 (Figure 15a, 16a) and 2014 (Figure 15b, 16b) events was most severe and widespread in the northern CNMI islands of Uracas, Maug, Asuncion, Pagan, Guguan, Sarigan, and Anatahan, as compared with the southern parts of the CNMI (Saipan and points south) and Guam. In particular, early reports from a monitoring cruise to the northern CNMI in July 2014, conducted by the CNMI Marine Monitoring and Coral Reef Program, indicated bleaching along

with signs of high coral mortality from the 2013 event, including over 90% mortality of *Pocillopora* and *Acropora* spp. By mid-August 2014, the survey team saw extensive bleaching and high mortality of *Pocillopora*, *Acropora*, *Astreopora*, and *Isopora* corals in Maug (northern CNMI), while bleaching around Guam and Saipan was documented to be serious, but much less severe.

In addition to indicating that most reefs in the northern CNMI reached unprecedented thermal stress levels in both 2013 and 2014, CRW's satellite monitoring showed that 2014 thermal stress levels (DHW<10) exceeded that of 2013 (DHW<6) (see example multi-year time series graph from Agrihan and Asuncion, CNMI, Figure 17). The thermal stress in 2014 also started about one month earlier, lasted two months longer, and reached its highest level about 1.5 months earlier than the 2013 event.

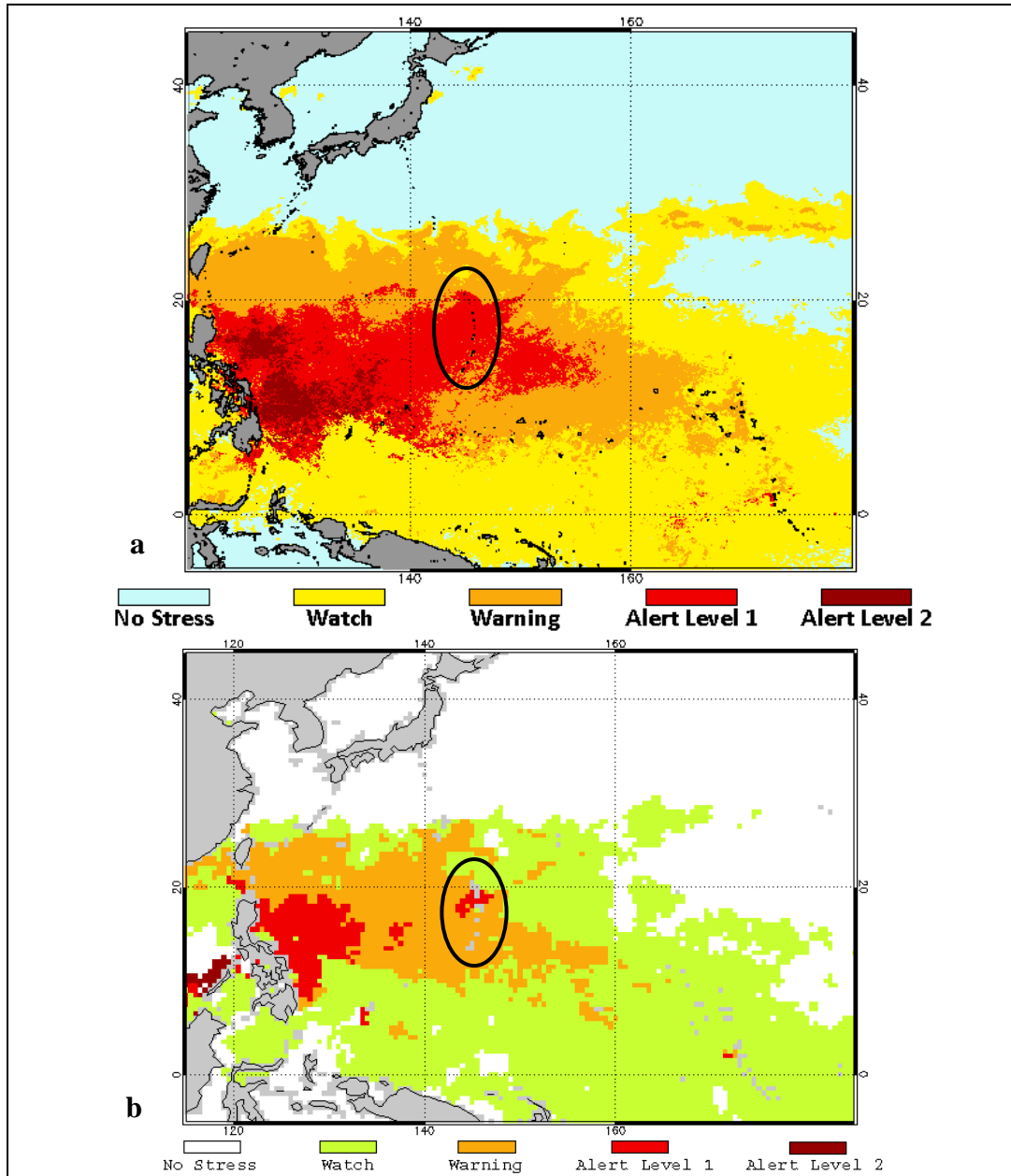


Figure 13. (a) NOAA CRW 5-km Bleaching Alert Area (7-day max) composite and (b) 50-km Bleaching Alert Area for the northwestern Pacific Ocean (with CNMI and Guam circled in black) – July 3, 2014.

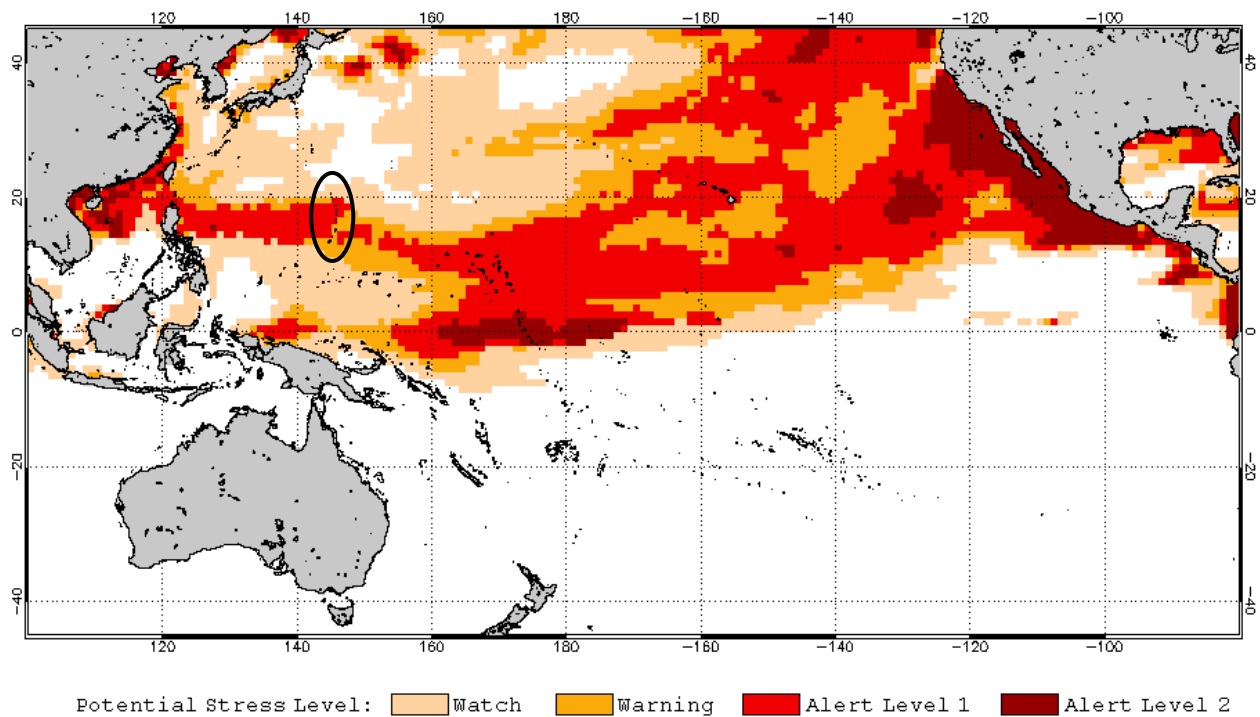


Figure 14. Map of potential coral bleaching (60% probability) in the Pacific Ocean (with CNMI and Guam circled in black) for July-October 2014 from NOAA CRW's Four-Month Coral Bleaching Thermal Stress Outlook (version 3) of July 1, 2014.

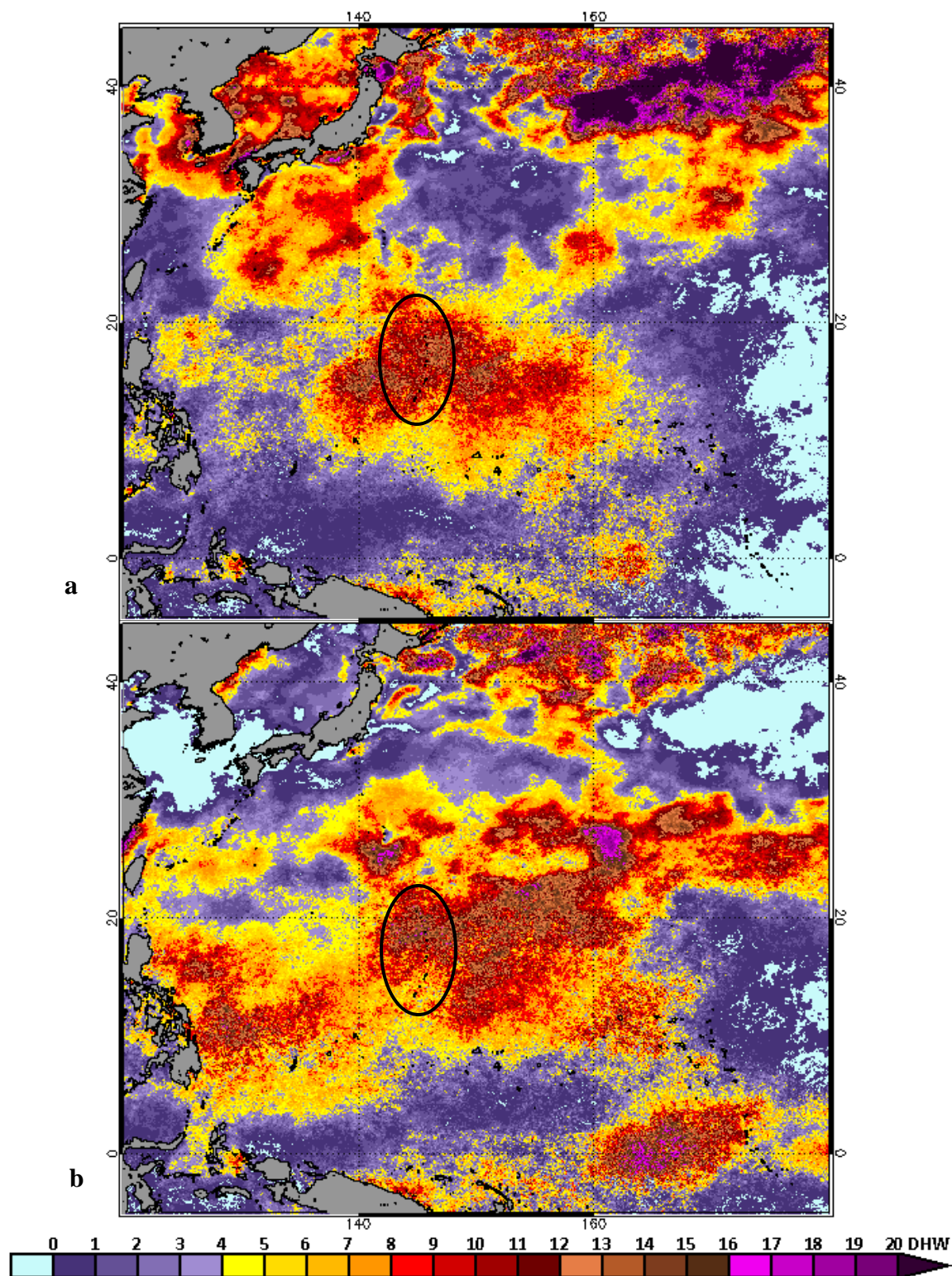


Figure 15. NOAA CRW Annual Maximum DHW for the northwestern Pacific Ocean (with CNMI and Guam circled in black) for: (a) 2013 [partial year: June 3-December 31 only] and (b) 2014.

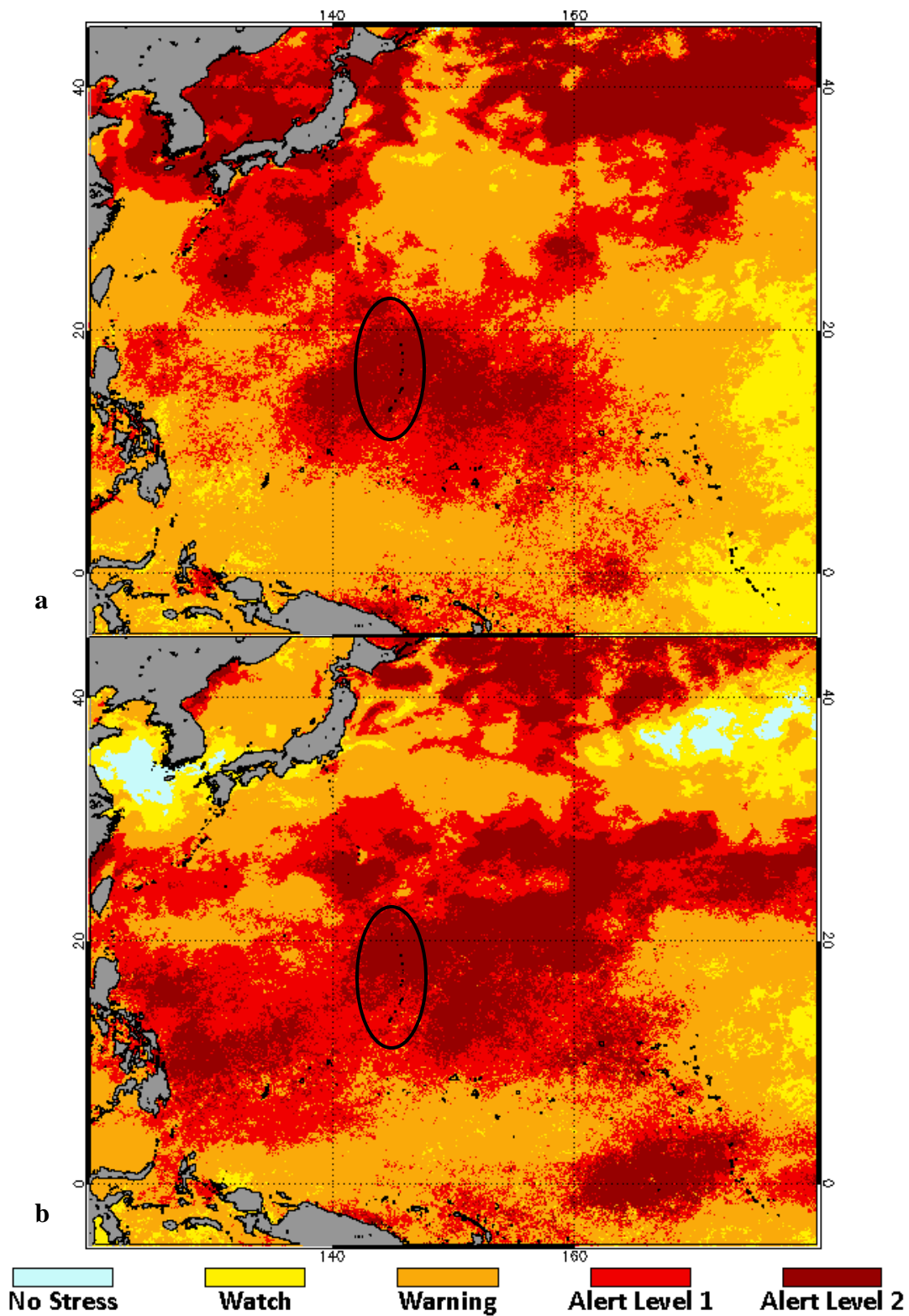


Figure 16. NOAA CRW Annual Maximum 5-km Bleaching Alert Area composite for the northwestern Pacific Ocean (with CNMI and Guam circled in black) for: (a) 2013 [partial year: June 3-December 31 only] and (b) 2014.

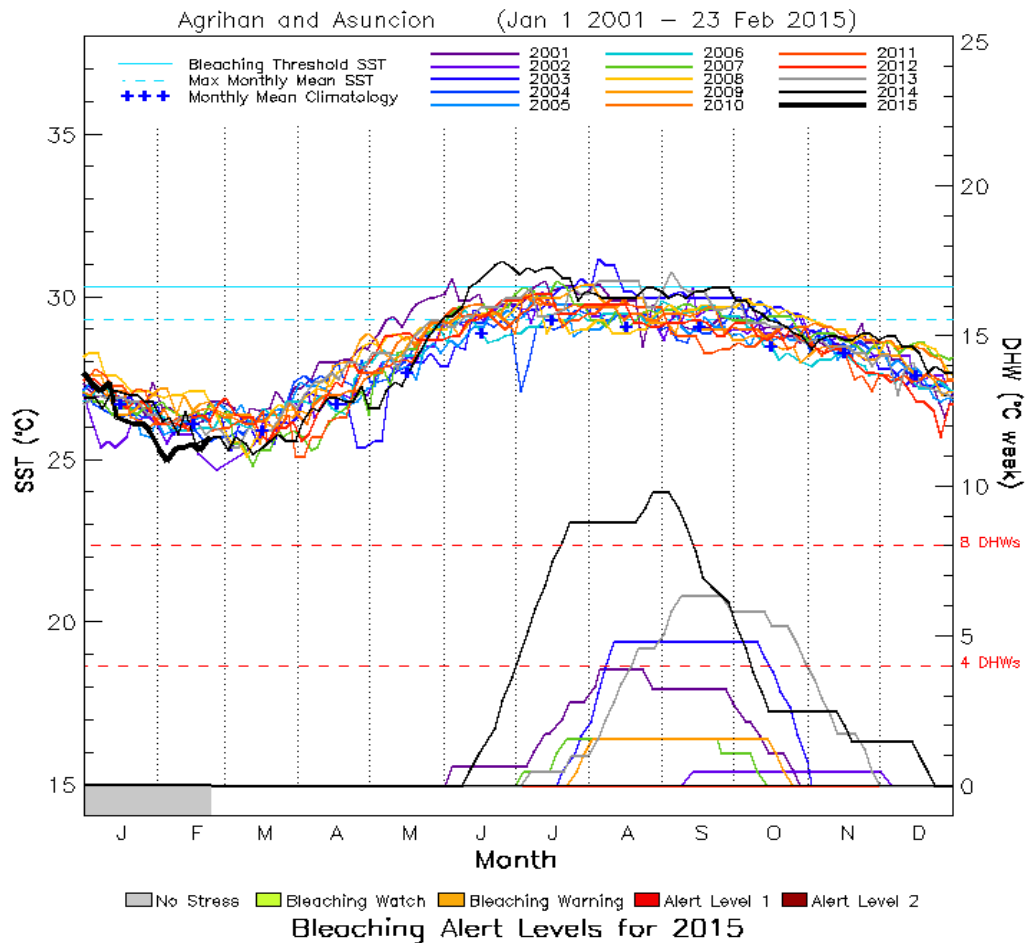


Figure 17. Multi-year time series graph for Agrihan and Asuncion, CNMI. While the northern portion of the CNMI reached unprecedented thermal stress levels in both 2013 and 2014, CRW's satellite monitoring indicates that the 2014 accumulated thermal stress (DHW<10, thin black line at bottom of graph) exceeded that of 2013 (DHW<6, thin gray line at bottom of graph); that the thermal stress in 2014 started about one month earlier; and that it reached its highest level about 1.5 months earlier than the 2013 event.

Program Partners:

